



# The IMPEX Data Model and Protocol

*A common standard for the analysis of simulated and observational space plasma physics data*

T. Al-Ubaidi<sup>1</sup>, M. Khodachenko<sup>1</sup>, E. Kallio<sup>2</sup>, V. Génot<sup>3</sup>, I. Alexeev<sup>4</sup>, M. Scherf<sup>1</sup>, F. Topf<sup>1</sup>, S. Hess<sup>3</sup>, R. Modolo<sup>3</sup>, M. Gangloff<sup>3</sup>, W. Schmidt<sup>2</sup>, N. André<sup>3</sup>, E. Belenkaya<sup>4</sup>

- 1) Space Research Institute, Austrian Academy of Sciences, Austria (IWF-OeAW),
- 2) Finnish Meteorological Institute, Finland (FMI)
- 3) Centre National de la Recherche Scientifique, France (CESR-CDPP; LATMOS)
- 4) Institute of Nuclear Physics, Moscow State University, Russia (SINP/MSU)

# Goals, Objectives

<http://impex-fp7.oeaw.ac.at>

**Scientific focus of IMPEX:** plasma and magnetic environments of...

- **Mercury** (BepiColombo)
- **Venus** (VenusExpress)
- **Earth** (Cluster, Themis)
- **Mars** (MarsExpress)
- **Jupiter** and **Ganymede** (Galileo, JGO)
- **Saturn** and **Titan** (Cassini)
- **Comet 67P** (Rosetta)

**IMPEX enables**

- **Selection, downloading, visualization and analysis** of data from **observations and modelling runs**
- Support in **finding matching modelling runs** and **request of specific runs**
- **Superimposing** modelling data with spacecraft measurements (*visual*)
- **Scientific tools and functionalities** for the support of preparation and operation of space missions (**virtual spacecraft** in modelled environment, *3DView*)

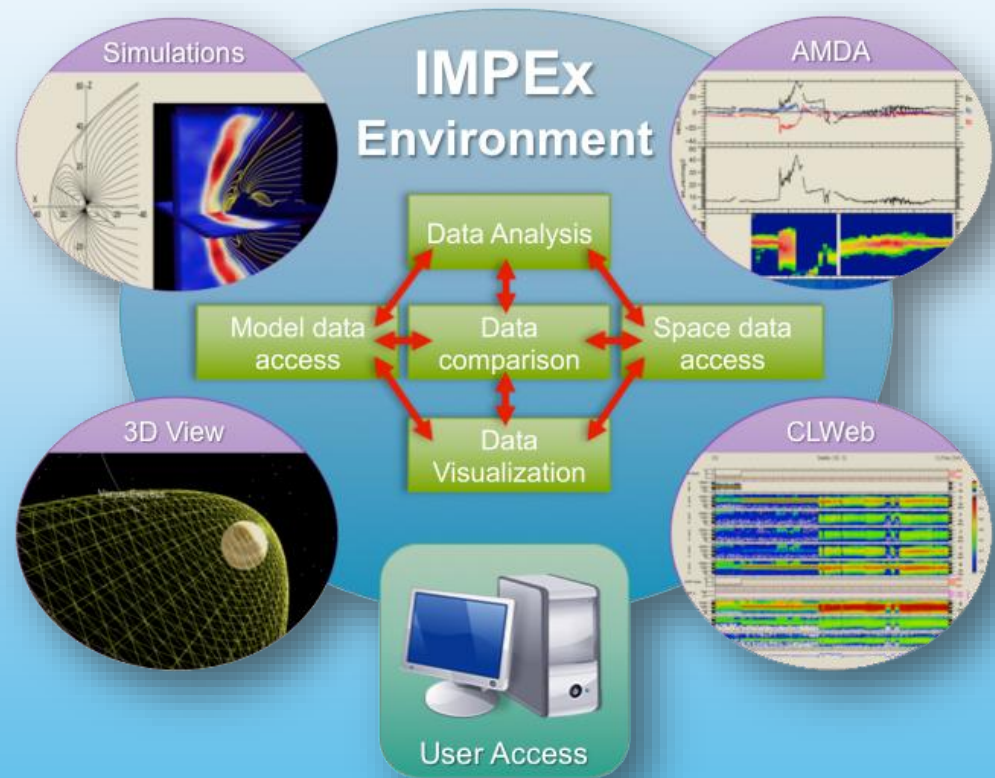
## Relation between the *current* set of models, tools and databases in IMPEX

### Simulation Models and Databases

- **3D hybrid & MHD** platforms  
(*FMI*, Finland)
- **3D hybrid** code (*CNRS/LATMOS*)
- **Paraboloid Magnetospheric Model**  
(*SINP*, Russia)

### IMPEX enabled tools

- **AMDA** sci. data access  
(*CNRS/IRAP-CDPP*)
- **3DView** visualization
- **CLWeb** data analysis
- **IMPEX Portal** (*under construction*)



# Basic principles

## Mandatory features of the IMPEX infrastructure

- **Extendibility** (easily adding of **new models, databases** and **analysis tools**)
- In-line with **worldwide trends and standards** (e.g. *IVOA*)
- **Generality** of approaches and **interoperability** with existing tools
- **Web-based** applications in a **service-oriented** environment



Can be seen as a prototype for a *general infrastructure* capable of operating a broad spectrum of *data and models*.

# The IMPEX Data Model

<http://impex-fp7.oeaw.ac.at>

- ❖ A common **metadata standard** was developed for the description of **simulation models** and **archived datasets**.
- ❖ **IMPEX Data Model** is based on **SPASE** (xml) that originated from the **Heliospheric community**.
- ❖ **SPASE** was developed for the **description of observational data**
- ❖ Ideal to add ability to describe respective simulation data on top and use it as a **unified Data Model** in the context of IMPEX.



# The IMPEX Data Model

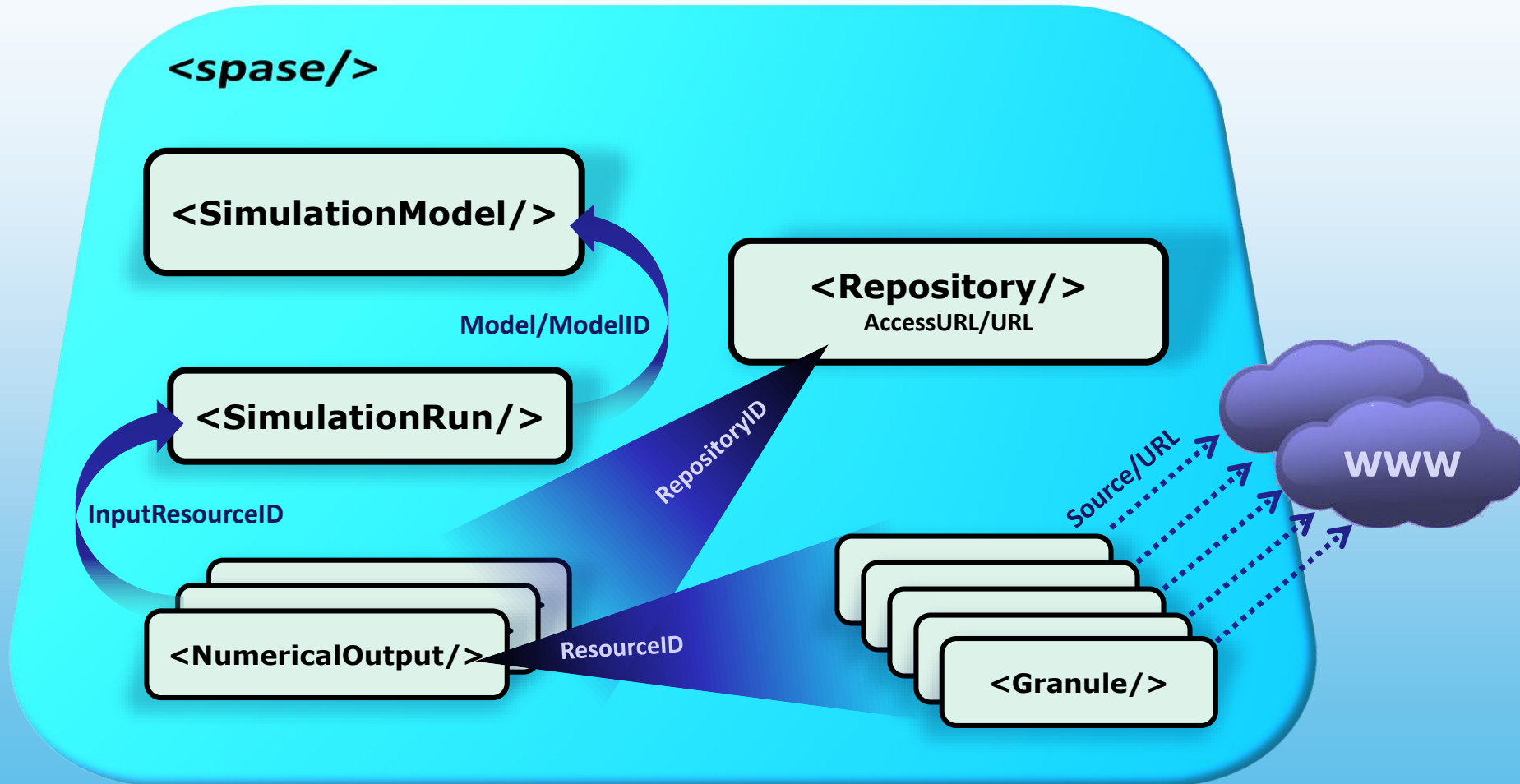
<http://impex-fp7.oeaw.ac.at>

- ❖ First **consistent data model** to **unify observational data and simulation outputs**
- ❖ Based on **SPASE 2.2.8 - Version 1.3** available since **July 2015**
- ❖ **Main components** of the are:
  - **<SimulationRun/>** Information about the **parameters used for the run**, refers to **detailed model description**
  - **<SimulationModel/>** Information about the simulation model, tracks the **version** used
  - **<NumericalOutput/>** Detailed information about a set of data files, refers to **simulation run** that generated the dataset.
  - **<Granule/>** Basic information about a data file (defines order within a data set) - refers to the **actual file and data set** containing the numerical output
- ❖ **Further extensions** regarding e.g. large data sets are being discussed for the **next update** (v1.4, 2017?).
- ❖ **IMPEX DM** scheduled to be integrated into **next major update of SPASE**



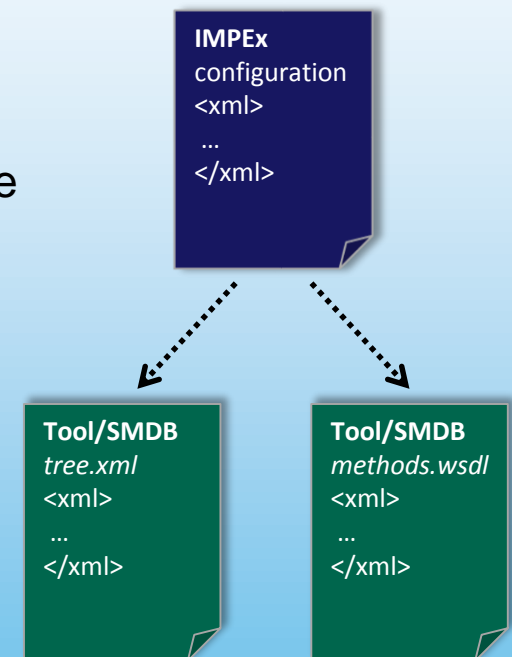
# The IMPEX Data Model

<http://impex-fp7.oeaw.ac.at>



## Central configuration file for access to methods and data

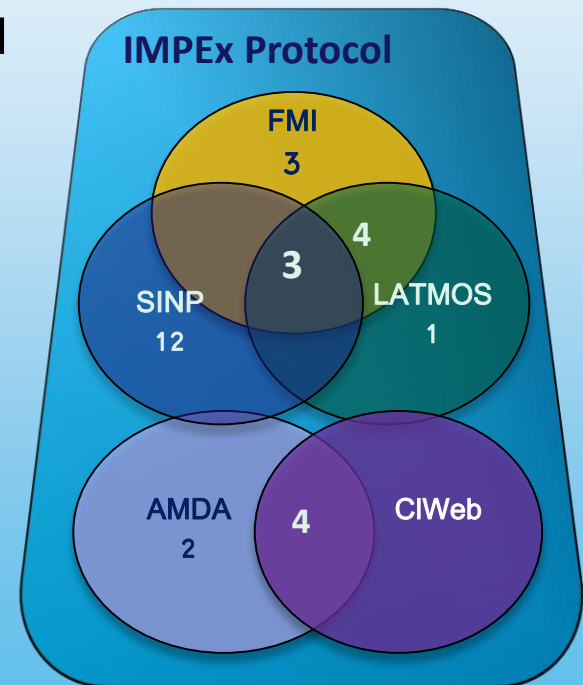
- ❖ The **IMPEX configuration file** (*impexconf.xml*) contains basic access information for every tool and every SMDB
  - The configuration file is **existing only once** for the whole system, the **caching policy** is part of the definition (see **Technical Documentation** on website)
  - Also includes the **technical protocol** to use for access and **basic information** about the service
- ❖ All data is accessible via the (static) **tree.xml** files. All data in the trees is stored **compliant with IMPEX DM**
- ❖ All available functionalities and methods are **accessible as a web service** as defined in the *methods.wsdl* file





## Common set of web services for SMDB and Tools access

- ❖ A very **challenging task** – diverse software systems (SMDBs) had to be unified under a common umbrella, i.e. **communication protocol**
- ❖ There are **28 methods** defined in total, **3 are shared** between all SMDBs and constitute the **core part**
  - **getDataPointValue**: Generic method to return data from 0D (given point) up to 3D (volume)
  - **getSurface**: Generates a meshgrid and compute interpolation for one or several parameters.
  - **getDataPointValueSpacecraft**: Interpolates simulation values along a given (spacecraft) *trajectory*.
- ❖ **AMDA** provides further methods for **data exchange** (i.e. *virtual workspace*).



## Usage of standard exchange formats and communication protocols

❖ The **main exchange formats** used by all methods defined in *method.xml* file are:

- **VOTable** - XML standard for the interchange of data represented as a set of tables
- **NetCDF** - software libraries and self-describing, machine-independent data formats

❖ On the client side **IMPEX uses SAMP** (*Simple Application Messaging Protocol*) for **inter-tool communication**

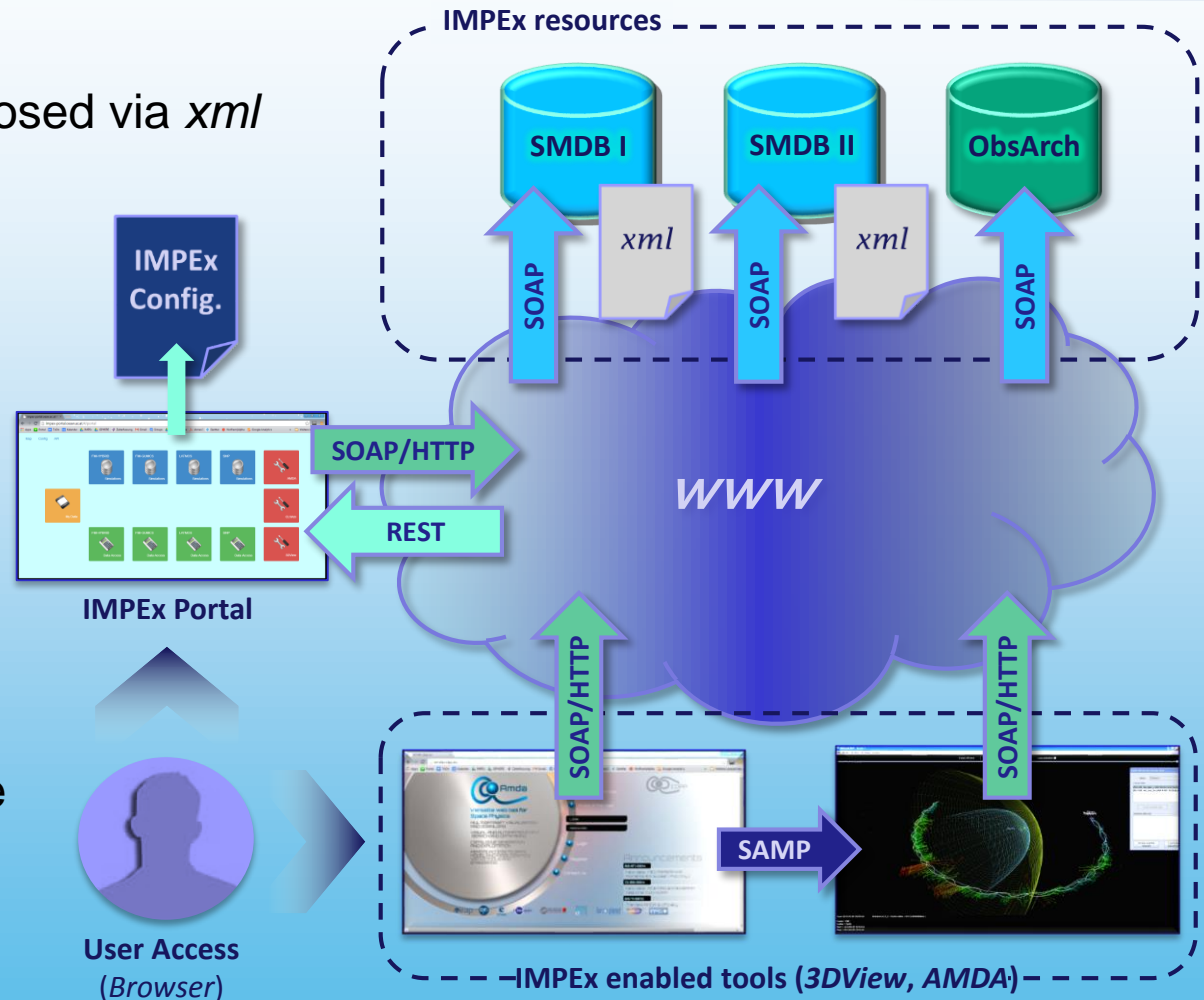
- **AMDA** and **3DView** use e.g. *SAMP* to exchange commands and data



# IMPEX Topology & Architecture

<http://impep-fp7.oew.ac.at>

- ❖ **Database structures** exposed via *xml* (**IMPEX DM**)
- ❖ Web Service interface (**SOAP/REST**)
- ❖ **IMPEX enabled tools**
- ❖ Central administration via **IMPEX configuration**
- ❖ **Central Access** to SMDB's via **IMPEX Portal**
- ❖ **SAMP Hubs** for client side communication



# IMPEX Webpage

<http://impex-fp7.oeaw.ac.at>



INTEGRATED MEDIUM FOR PLANETARY EXPLORATION

IMPEX Overview

IMPEX Tools

Modeling

Demonstrators and Tutorials

Technical Documentation

Use and Science Cases

IMPEX Science News

Publications & Talks

Project Partners

IMPEX Core Team (PMC)

Comments & Feedback

Horizon 2020

Preparing for Horizon 2020

IMPEX Technical Documentation

This page collects all technical documentation relevant to the IMPEX environment and the IMPEX protocol. Existing documents will be updated on a regular basis - new material will be added as needed.

IMPEX Simulation Data Model (v1.0.1)

Comprehensive description

Data Model [XML Schema](#) ([xsd](#))

Full documentation of the XML Schema as [html](#) or [pdf](#).

Interface Control Documents (ICD)

The Interface Control Documents provide all required details of the various implementations of the IMPEX protocol including examples and best practices.

[AMD ICD \(v1.4\)](#) [SIMP ICD \(v0.7\)](#) [LATHOS ICD \(0.5\)](#) [FMI ICD \(0.9.1\)](#)

IMPEX Configuration

Comprehensive description

IMPEX configuration [XML Schema](#) ([xsd](#))

The configuration file can be retrieved as [xml](#) or [json](#).

IMPEX Service Response Formats

All the Web services provided by IMPEX return data either in [netCDF](#) or in [VOTable](#) format, depending on the user's request.

Documentation for [netCDF](#) as [html](#).

Documentation for [VOTable \(v1.1\)](#) as [html](#) and [XML scheme](#).

## IMPEX Webpage

<http://impex-fp7.oeaw.ac.at>

Developed by **IWF-Team in Graz**  
based on *Typo3 CMS*.

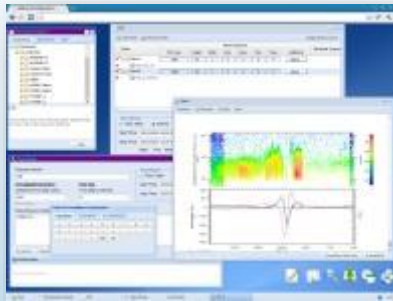
## Information about

### ❖ Technical Documentation

- ❖ Project **activities** and news
- ❖ Project **meetings**
- ❖ **Publications** and talks
- ❖ Project **science** news
- ❖ **Collaborations** with other projects
- ❖ **Podcast**

# The IMPEx Tool-Set

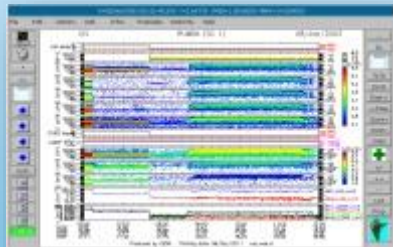
<http://impex-fp7.oeaw.ac.at>



**AMDA** - <http://cdpp-amda.cesr.fr/>



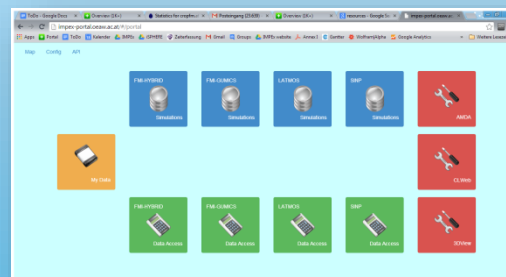
**HWA** - <http://hwa.fmi.fi/>



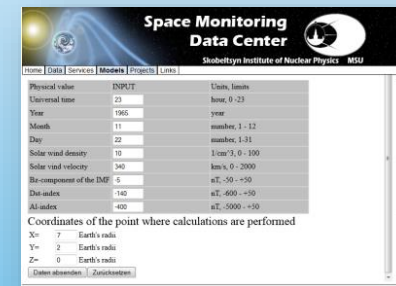
**CLWeb** - <http://clweb.cesr.fr/>



**3DView** - <http://3dview.cesr.fr/>



**Portal** - <http://impex-portal.oeaw.ac.at>



**SINP** - <http://smdc.sinp.msu.ru/>



**THANK YOU!**  
***QUESTIONS, COMMENTS...?***